1. Which of these traits would be characteristic of an r-strategist?

   A. Large final size
   B. **Good dispersal**
   C. Production of a small number of high-quality offspring
   D. Good competitive ability
   E. Iteroparity

2. The value f_x in a life table incorporates: survival of the x year old individual from __________, survival of new individuals from the reproductive period to the census time, and __________ the number of new individuals produced by an individual during the reproductive period.

   A. the reproductive period to the census time; not
   B. the reproductive period to the census time; also
   C. the census time to the reproductive period; not
   D. **the census time to the reproductive period; also**

3. Which of the following is *not* usually an advantage of dispersal:

   A. **More likely to find a suitable habitat**
   B. Less likely to compete with siblings
   C. Distributes risk (bet hedging)
   D. Genetic mixing

4. A correct mathematical explanation for bet-hedging strategies is that: organisms average over environments __________ generations to achieve a higher mean; the __________ mean.

   A. **within; arithmetic**
   B. within; geometric
   C. between; arithmetic
   D. between; geometric

5. If every individual of an annual species has 100 offspring, which are dispersed such that within any year half of them land in good spots (5% survival) and half of which land in bad spots (1% survival), which of the following is closest to its long-term average growth rate?

   A. 0.5
   B. 1
   C. 2.2
   D. **3**
   E. 6

6. A pile of radioactive material is decaying *continuously* at an instantaneous rate of 1% per minute. After two minutes, what proportion is left?

A. **A little more than 98%**
B. Exactly 98%
C. A little less than 98%
D. About 30%
E. None

7. A population meets the assumptions of the balance argument for sexual allocation. If the population has more females than males at birth, this means that, on a ________ basis, there is ________ investment of resources in in producing females than in producing males

A. population; higher
B. population; lower
C. Per-offspring; higher
D. **Per-offspring; lower**

8. Which of the following is *not* an example of a tradeoff?

A. **Birds with heavier beaks are more efficient at cracking seeds and better at defending territory**
B. Bushes which survive better in dry conditions grow more slowly in wet conditions
C. Trees which grow fastest in full sunlight have higher mortality in the shade
D. Rabbits which need less food to survive produce fewer offspring when food is plentiful

9. Which of the following would you expect to lead to a population producing more females than males at birth?

A. Increased cost of producing females
B. Higher population density
C. Lower population density
D. Greater variation in male reproductive success
E. **Restricted dispersal leading to within-family mating**

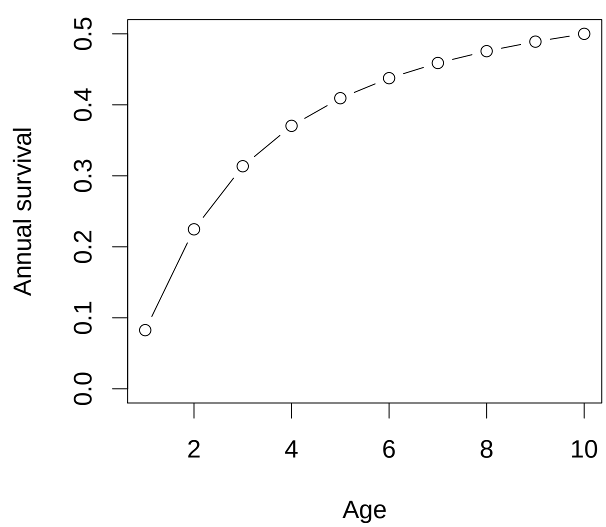
Increased cost of producing females would *decrease* the number of females. The rest of the possibilities wouldn't be expected to have an effect on the *population-level* output (although variation in male reproductive success might lead individuals to skew their output one way or the other).

10. If we are thinking about a simple, continuous-time model, then for a population to be regulated:

A. **The average reproductive number $\mathcal{R}$ must be low at high density and higher at either low or intermediate density**
B. The birth rate b must be low at high density and higher at either low or intermediate density
C. The death rate d must be high at high density and lower at either low or intermediate density
D. All of the above

11. Polio has a finite-time growth rate λ of about 11, and a generation time of about 10 days. If we start with one case, about how many cases do we expect to see (provided there is no density-dependence) 20 days later?

A. 2.2
B. exp(2.2)
C. 22
D. **121**
E. 220

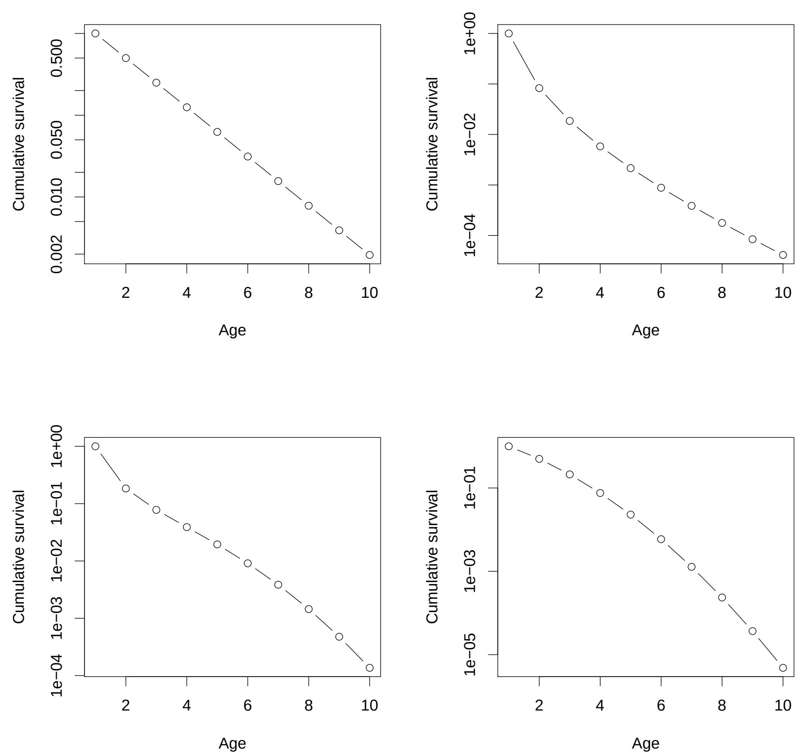


Use the picture above for the following 2 questions.

12. What does this picture of survivorship in an idealized age-structured population indicate about *mortality* in this population?

A. Mortality is constant
B. Mortality is elevated in older individuals
C. **Mortality is elevated in younger individuals**
D. Mortality is elevated in both older and younger individuals

13. The pictures below show *cumulative* survival. Which one corresponds to the picture shown above?



ANS: B

14. Which of the following is true of the age distribution of a decreasing population with a constant life table?

A. It matches the ℓ_x curve exactly
B. **It is more top-heavy (more individuals in older age classes) than the ℓ_x curve**
C. It is more bottom-heavy (more individuals in younger age classes) than the ℓ_x curve
D. Insufficient information to answer
E. A population can't be decreasing if it has a constant life table

a stable population has $R = \lambda = 1$, so the SAD is proportional to $\ell_x \lambda^{-x} = \ell_x 1^{-x} = \ell_x$. Since $\lambda < 1$, bigger values of x are relatively large compared to ℓ.

15. The carrying capacity for an organism in an environment is the density at which crowding reduces the average of ___________ to zero:

A. The birth rate
B. The death rate
C. The recruitment rate
D. The amount of free habitat
E. **The difference between the birth rate and the death rate**

16. A population of oak trees is estimated to be at stable age distribution, with a constant life table, with reproductive number $\mathcal{R}$= 1.2. It takes the trees several decades to reach maturity and reproduce. This population is

A. declining
B. stable
C. **increasing**
D. showing damped oscillations
E. there is not enough information to answer this question

17. If an annual species produces an average of 10 offspring in odd years and an average of 1 offspring in even years, which of the following is closest to its long-term average growth rate?

A. 1
B. 3
C. **3.2**
D. 5.5
E. 10

This is the geometric mean of 10 and 1 = $\sqrt{10} \approx 3.2$

18. A rat population is growing without any population regulation. Females produce an average of 1.6 offspring each year for two years. The probability of each offspring surviving to reproduce is 0.5; one-year-old rats survive to age 2 with probability 0.8; two-year-old rats never survive, because they don't want your life table to be too long. The sex ratio in the population is 1:1.

a) (2 points). Explain *briefly* how you calculate the values of f_x for this population. You should explain whether you are counting before or after reproduction (either is fine).

If we count before reproduction, f_x includes the number of offspring produced, and the probability that they will survive to be counted again. Since the amount of reproduction is given only on a per-female basis, we need to multiply by the sex ratio to find the number of females produced. Thus f_1 and f_2 are the same and equal 0.5 * 1.6 * 0.5 = 0.4.

b) (2 points). Explain briefly what values you use for p_x to be consistent with your census choice in the previous answer.

p_x is the probability that an individual counted in group x will survive to be counted the next year. We need this to match our choice for when we count. Since we count before reproduction, we want the probabilities that 1 (or 2) year old adults will survive until the next year. These are 0.8 and 0.

c) (1 point) Explain briefly what ℓ_x means, and show how you calculate the values.

ℓ_x is the probability of surviving from the first time being counted until age group x. ℓ_1 is always 1. We get ℓ_2 by multiplying ℓ_1 by $p_1 = 0.8$ to get 0.8.

d) (1 point) Fill in the life table and calculate $\mathcal{R}$ for this population.

x	f_x	p_x	ℓ_x	$\ell_x f_x$
1	0.4	0.8	1	0.4
2	0.4	0	0.8	0.32
$\mathcal{R}$				0.72

If instead we count after reproduction, f_x is the product of the probability of survival to the next reproductive season, and the number of offspring produced. We still need to multiply by the sex ratio to find the number of females produced. f_1 is therefore 0.5 * 1.6 * 0.5 = 0.4, and f_2 is 0.64.

If we count after reproduction, we want the probabilities that newborns and 1-year-old adults survive until the next year. Newborns survive with probability 0.5. As explained in class, we usually assume that two-year-olds die by the time we count after reproduction, so we could say that $p_2 = 0$ and end the table. We could also say that $p_2 = 0.8$ and make a third line in our life table. This line won't affect our calculations, because the two-year-olds aren't going to survive to produce any offspring, so their contribution ℓf will be zero.

ℓ_1 is still always 1, so ℓ_2 is 0.5.

x	f_x	p_x	ℓ_x	$\ell_x f_x$
1	0.4	0.5	1	0.4
2	0.64	0	0.5	0.32
$\mathcal{R}$				0.72

e) (1 point) Write an expression showing the relationship between λ, $\mathcal{R}$ and 1 (e.g., $\lambda > \mathcal{R} = 1$ or $\lambda < 1 < \mathcal{R}$).

Since $\mathcal{R} < 1$, we know $\lambda < 1$. Since λ is the increase on the time scale of a year, and $\mathcal{R}$ is on the time scale of a lifetime, and the organisms can reproduce in more than one year, we know that λ must be *closer* to 1 than $\mathcal{R}$ is, so we write $\mathcal{R} < \lambda < 1$.

f) (1 point) Write an equation that you could use to calculate λ for this population. Fill in numbers for all values except for λ.

$\sum \ell_x f_x \lambda^{-x} = 1$ (from the formulas section). We can just fill in the products from our life table: $0.4\lambda^{-1} + 0.32\lambda^{-2} = 1$.